SP-F15 Evaluation of the Feasibility to Provide Passage for Targeted Species of Migratory and Anadromous Fish Past Oroville Facility Dams

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1.0 Introduction/Background

Historically, the upper Feather River watershed provided habitats for anadromous and resident salmonids. Spring-run chinook salmon and steelhead were known to ascend the very highest streams and headwaters of the Feather River watershed while fall-run chinook salmon occupied the lower foothill reaches (Yoshiyama et al. 1998; California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (USBR) 2000). As part of the Oroville Facilities, the Fish Barrier Dam was constructed during the early 1960s. Located upstream of the Feather River Hatchery and approximately five miles below Oroville Dam, it is identified as the first impassible salmonid migration barrier on the Feather River (Yoshiyama et al. 1996; California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (USBR) 2000).

The spatial distribution of spring-run chinook salmon was considerably reduced prior to the 1960s by the construction of hydropower dams and diversion projects upstream of the Oroville Facilities. For instance, in 1959 DFG found substantial overlap in the spawning distributions of fall-run and spring-run chinook salmon upstream of the Oroville Dam site (DWR and USBR 2000). Since construction of the Oroville Facilities, most of the spawning activity of spring-run and fall-run chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) has been limited to the reach of the Feather River extending from the Fish Barrier Dam to the Thermalito Afterbay Outlet (DWR 2001). Approximately 25 percent of chinook salmon spawning occurs in the reach of the Feather River extending from the Thermalito Outlet to Honcut Creek (Sommer et al. 1998). In addition to anadromous salmonids, the Oroville Facility dams also prohibit upstream passage of other migratory species (e.g. sturgeon), which are unable to pass the Fish Barrier Dam.

Providing passage into Lake Oroville's upstream tributaries may diminish certain project-related migration limitations caused by current barriers (e.g. Fish Barrier Dam) and return fish to potentially suitable spawning, rearing and holding habitats. Providing passage to the upstream tributaries potentially offers several benefits which differ from those currently provided by the ongoing Feather River hatchery operations and may serve as an alternative means of improving endangered species recovery.

Currently, the Oroville Facilities rely heavily on hatchery production to repopulate depressed stocks of chinook salmon and steelhead. Providing fish passage upstream may not only enhance existing production in the Feather River system but may develop a more robust and stable population over time. Providing opportunity for spatial segregation of fall-run and spring-run chinook may benefit overall genetic diversity. One potentially valuable application of separating components of populations could include providing passage for chinook salmon exhibiting spring-run life history above the Fish Barrier Dam into the Fish Barrier Pool. This may allow early-arriving chinook salmon to hold in the Fish Barrier Pool prior to entry into the hatchery, and may facilitate reduced genetic introgression between chinook salmon exhibiting spring-run life history and fall-run life history. Providing for fish passage above the existing upstream barriers, would allow adult fish to

spawn in the upstream tributaries and allow their offspring (i.e. alevins and juveniles) to develop without the interference of human manipulation and handling.

SP-F15 is designed to assess the feasibility of providing fish passage over, around or through the Oroville Facilities. Fish species (i.e. anadromous salmonids including spring-run and fall-run chinook salmon and steelhead) under consideration for passage alternatives in SP-F15 include those that were found in the upstream tributaries of the Feather River prior to the construction of Oroville and other hydropower and diversion projects as well as other migratory species found in the Feather River below the Fish Barrier Dam, including sturgeon. Because sturgeon have the potential to reach the Fish Barrier Dam, were historically found in upper tributaries of the Feather River prior to Oroville Dam construction, and were stocked in Lake Oroville in 1988, it is reasonable to consider potential passage alternatives into and out of Lake Oroville for the possibility of developing or enhancing the sturgeon fishery within project waters. There is little documented information regarding sturgeon distribution, life history, habitat requirements and conservation needs as compared to anadromous salmonids such as salmon and steelhead. Passage feasibility alternatives for sturgeon will also be considered in SP-F15.

The geographic scope of the proposed study area includes Lake Oroville, its upstream tributaries extending up to the first migration barrier, the Thermalito complex, the Diversion Pool and the Fish Barrier Pool. The characteristics of each upstream tributary will be evaluated independently due to the large geographic area and numerous possible passage-related alternatives that may be appropriate. This approach is logical because fish of one species could be captured at one location or point in time along the Feather River and transported to another site, or multiple sites, while another species could be captured at an unrelated location, or a different point in time and transported upstream into yet another completely different habitat according to appropriate life history and habitat requirements. As a result of complexities in scope and other differences in fisheries resources, habitat, and management objectives, each potential passage alternative in SP-F15 will be evaluated according to distinct geographic units.

In addition to reaches of the Feather River below the Fish Barrier Dam, there are upstream locations that have the potential to provide spawning, rearing and holding habitat for anadromous salmonids. The geographic extent of salmonid spawning distribution prior to the construction of Oroville Dam is an important basis of information to determine the upstream extent of potential protection, mitigation and enhancement measures (PM&Es) pertaining to fish passage that may provide benefits. The historical distribution of salmonid spawning habitat will be determined (Task 2) as a means of ascertaining the entire potential geographic range and quantity of suitable habitat that could be utilized. However, because the majority of this potential habitat lies beyond the geographic confines of this study plan (SP-F15), a separate feasibility evaluation will be performed in ~~SP-F15C~~the cumulative effects analysis, which will consider the cumulative effects ~~of providing~~ on interference with passage ~~for~~ on targeted ~~species of~~ migratory and anadromous fish into the upper tributaries of the Feather River that extend beyond the first migration barrier above Lake Oroville.

The overall objective of SP-F15 is to provide a GIS-driven decision support tool which will be designed to describe the merits and desirability of individual fish capture, sorting, holding, transport and release alternatives, or combinations thereof, and rank the feasibility for each component that could be implemented in the upper Feather River basin to provide fish passage and improve self-sustaining in-river fish production

within the system. Because of the complexities in scope and the potential applicability of extensive combinations of passage alternatives that are associated with this study plan, the design of the decision support tool will provide flexibility for the consideration of feasible alternatives. If new possibilities arise during the evaluation process, assessment provisions described in Tasks 1, 2, 3, and 4 would be applied to ensure full inclusion of alternatives. This tool is designed to facilitate ~~negotiation~~ identification of reasonable protection, mitigation and enhancement measures (PM&Es).

2.0 Study Objectives

The study plan objective is to evaluate the feasibility of alternatives designed to provide passage for migratory and anadromous fish into waters upstream of the Fish Barrier Dam and extending to the first upstream migration barrier above Lake Oroville. Passage feasibility will consider a range of alternative methods and devices that would be appropriate for the physical conditions of each identified geographic unit and for each target species, taking into account life history and habitat requirements. Additionally, the study plan will provide a foundation for future evaluations and development of potential protection, mitigation and enhancement measures (PM&Es).
Individual task objectives include:

- Summarize life history and habitat requirements for all targeted fish species (Task 1);
- Summarize historical and current habitat available for holding, spawning and rearing (Task 2);
- Develop a set of maps illustrating historical spawning extent, facilities, adjacent land ownership, existing fish barriers, coded reaches indicating quantity and quality of habitat, roads and railroads (Task 2);
- Summarize methods and devices used for fish capture, sorting, holding, transport and release (Task 3);
- Describe site condition summaries of existing passage barriers and study reaches (Task 4A);
- Develop a matrix of alternatives/locations/considerations that will follow a gated process and serve as a means of prioritizing alternatives (Task 4B):
    - Develop a list of the alternative mechanisms;
    - Develop a weighted description/evaluation of each mechanism (based on the literature review) and narratives explaining the rationale used to assign individual rankings;
    - Develop biological and cost associated ranking profiles (i.e. highly feasible, potentially feasible, not likely to be feasible);
    - Identify possible options to modify the scores (i.e. if by changing one factor, the alternative would become feasible);
- Develop a GIS decision support tool (Task 4C):
    - This tool will draw upon information taken from the weighted matrix (Task 4B) and the set of maps (Task 2) to provide a means of evaluating the feasibility of all possible combinations of fish passage alternatives. This decision support tool will be used to facilitate negotiation of PM&Es.

3.0 Relationship to Relicensing/Need for Study

This study is necessary because ongoing project operations and facility structures impede or restrict passage of anadromous and migratory fish in the Feather River above the Oroville Facilities. Anadromous salmonids migrating up the Feather River to spawn are currently stopped at the Fish Barrier Dam. Because they are unable to pass over, around or through the Oroville Facilities, potential upstream spawning habitat is inaccessible.

This study will provide an evaluation based upon available information including reports, scientific papers, past surveys and other information such as photographs, maps, and/or newspaper articles, to evaluate the feasibility of providing passage for adult and juvenile migratory and anadromous fish past the Oroville Facility dams. While some information on habitat quality of the upstream tributaries has been collected by other projects, anadromous salmonid habitat availability and suitability data for Lake Oroville's upstream tributaries up to the first migration barrier will be obtained from SP-F3.1. SP-F3.1 will also provide information regarding the habitat in Lake Oroville, the Thermalito Forebay, Thermalito Afterbay, Diversion Pool and SP-F3.2 will provide information on the Fish Barrier Pool. Additionally, there is a need to collect, catalogue and evaluate the experiences and knowledge gained at other dams that use passage facilities (e.g., fish ladders, fish elevators, bypass systems) and transportation methods (e.g., trap-and-truck, trap-and-barge) to provide passage for adult and juvenile anadromous salmonids and other migratory species.

The feasibility evaluation provided by this study will complement the assessments of project-related effects on the passage of in-river fish to and from available fish habitat upstream of Lake Oroville, and within the lower Feather River (SP-F5/7 and SP-F10, respectively). These assessments and the present feasibility study will be important components in the evaluation of effects of the Oroville Facilities required to comply with National Marine Fisheries Service (NMFS) federal Endangered Species Act (ESA) consultation information requirements and Section 18 of the Federal Power Act.

Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the FERC Application for License for major hydropower projects, including a discussion of the fish, wildlife and botanical resources in the vicinity of the project. The discussion needs to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operation of the project. In addition to fulfilling these requirements, information developed in this study plan also may be used in determining appropriate protection, mitigation and enhancement (PM&E) measures.

4.0 Study Area

The proposed study area encompasses the Feather River upstream and downstream of the Fish Barrier Dam, including but not limited to FERC project waters comprised of Lake Oroville, its upstream tributaries, the Thermalito Complex, the Fish Barrier Pool, the Diversion Pool. This includes areas of the upper Feather River watershed within the fluctuation zone of Lake Oroville to the high water mark. The upstream tributaries of Lake Oroville consist of four major tributaries: the North Fork Feather River, the West Branch of the North Fork Feather River, the Middle Fork Feather River and the South Fork Feather River. The upstream extent of this study area extends to the first stream channel obstructions that completely block upstream migration of

anadromous salmonids. The upstream migration barriers on the tributaries have been definitively identified in Task 1A of SP-F3.1. Additionally, the geographic scope may include selected potential alternative transport and release locations.

The range of geographic alternatives may change during this process, depending upon the findings and determinations that are made as a result of further consideration and review. ~~Adapting the geographic scope would not impact costs or feasibility considerations because this study plan only involves literature review and desktop analysis.~~ Study plans approved by the Environmental Work Group define the limits of the study area. If initial study results indicate that the study area should be expanded or contracted, the Environmental Work Group will discuss the basis for change and revise the study area as appropriate.

5.0 General Approach

Because this is a feasibility study, study plan SP-F15 will consider, evaluate and provide rationale for both:

A. Possible alternatives, or combinations thereof, which may be used in one or several of the various aspects of restoring fish passage in the upper tributaries of the Feather River. Passage considerations for the area beginning in the Feather River below the Fish Barrier Dam and extending into the Feather River upstream tributaries above Lake Oroville will encompass five discrete steps (capture, sorting, holding, transport and release) to be applied to fish moving both upstream and downstream in the system. Each of these steps will involve a review of all alternative methods and devices that could potentially be employed as a means of providing fish passage past the Oroville Facilities (Task 3).

   These alternative mechanisms will fall into one or more of the following categories: (a) capture of fish (adults) in the Feather River downstream of the Fish Barrier Dam; (b) sorting of fish (adults and juveniles of target and non-target species) below the Fish Barrier Dam; (c) holding sorted fish below the Fish Barrier Dam; (d) transport of adult fish from the sorting facility to the release destination; (e) release of fish (adults) into the designated water body; (f) capture of adults (species dependent) and juvenile fish; (g) sorting of captured fish (adults and juveniles of target and non-target species); (h) holding sorted fish prior to downstream transport; (i) transport of fish (juveniles and adults of some species) downstream to below the Fish Barrier Dam; (j) release of fish below the Fish Barrier Dam.

B. Options that have been considered in the initial review and evaluation process (Task 3) but were determined to be infeasible or undesirable alternatives based upon existing knowledge, literature review findings, known physical limitations of a particular site, professional judgment, etc. Rationale explaining the basis of not considering these options further (i.e. carrying them forward into Task 4) will be provided as justification for only a cursory review.

This study plan is divided into four primary tasks, all of which will address different aspects of consideration necessary for determining potential alternatives, desirability and technical feasibility associated with passing fish over, around or through the Oroville Facilities. SP-F15 will involve intensive desktop study/literature review consisting of identification, comparison and evaluation of all available information focusing on alternative fish passage facilities, structures, devices, measures, methods (Task 3) or any combination

thereof, necessary for safe, timely and effective movement of anadromous salmonids and other migratory fish, inclusive of all appropriate life stages (Task 1), and evaluation of their potential application to the Oroville Facilities for capturing, sorting, holding, transporting and releasing adult and juvenile fish over, above or through dams, reservoirs, and diversions (e.g. fish ladder, fish elevator, bypass channel). Species-specific habitat requirements for adult and juvenile fish (Task 1) will also be taken into account during the analysis to assist in the identification of which areas of existing habitat within the project waters and upstream tributaries (Task 2) below the first migration barrier above Lake Oroville may be best suited to provide spawning, rearing and holding habitat for transported adult fish and their offspring.

This assessment will be conducted using the best available information to characterize the components associated with fish passage (e.g. extent of historical spawning habitat, existing habitat conditions, life histories and habitat requirements of targeted anadromous and migratory species) as well as the methods and devices that could potentially be used during all phases of fish passage and movement between the Feather River, project waters and the upstream tributaries. Potential sources of information include but are not limited to reports, scientific papers, surveys by DWR and other agencies, and other information (photographs, maps, aerial photos). Another informational resource, the Annotated Bibliography on Fishery Questions Related to the Reintroduction of Anadromous Fish Over High Head Dams (1994), may also be used during the literature review that is associated with the study plan tasks. This annotated bibliography contains 733 references to published and unpublished sources and covers topics including disease, parasites, risk-assessment and general risks of species introductions, previous success with attempted reintroductions of anadromous salmonids, management strategies for increasing anadromous salmonid outmigration with emphasis on collection and transportation methods, trophic dynamics and effects of flow and discharge.

Once the above information has been compiled and reviewed, it will be synthesized into a weighted matrix (Task 4B), which in turn will assist in providing feasibility ranking profiles for each passage alternative, or combination thereof, as determined from a GIS-derived decision support tool (Task 4C). Periodic verbal interim reports will be provided to summarize preliminary results of the literature review identifying and describing the information relating to Tasks 1, 2, 3, and 4. These iterative reports will provide updates to the collaborative throughout the process of study design and implementation and will facilitate discussion regarding potential adjustments to the focus of the analysis. If initial study results indicate that the methods and tasks should be modified, the Environmental Work Group will discuss the basis for change and revise the study plans as appropriate.

Geographic Units and Major Tributaries to be taken under consideration:

Evaluations of each level of activity associated with providing fish passage will be made according to distinct geographic units. In order to develop a decision support tool, the study area will be divided into distinct geographical areas as follows:

- Below the Fish Barrier Dam
- Fish Barrier Pool

- Diversion Pool

- Lake Oroville above the Dam

- Oroville Tributaries below Lake Oroville's high water mark
  - West Branch of the North Fork Feather River
  - North Fork Feather River
  - Middle Fork Feather River
  - South Fork Feather River

- Oroville Tributaries below the first fish barrier but above Lake Oroville's high water mark (including but not limited to the following)
  - Sucker Run Creek
  - West Branch of the North Fork Feather River
  - North Fork Feather River
  - Middle Fork Feather River
  - South Fork Feather River

- Potential locations where juvenile fish are released downstream
  - Feather River below the Oroville Facilities

Detailed Methodology and Analysis

Task 1: Describe the Life History and Habitat Requirements of Feather River Anadromous Salmonids and Other Migratory Species.

Information on the specific life history and habitat requirements of targeted species or runs of Feather River anadromous salmonids and other migratory fish is necessary to effectively evaluate the timing of juvenile and adult migrations, the factors affecting timing, and the success of juvenile and adult migrations. These factors may influence the feasibility of providing passage and include such elements as: habitat preferences, water temperature requirements, predation risks, susceptibility to disease, and mortality rates due to handling and transport by species by life stage.

Four species found in the Feather River have been targeted as potential candidates for passage into upstream sections of the Feather River watershed that are currently impassible due to fish barriers. These include:

Anadromous salmonids:

- For the purpose of this study, the term "anadromous salmonids" includes three runs of Feather River salmonids that spawn below the Feather River Fish Barrier Dam. These species include: fall-run and spring-run chinook salmon and steelhead.

Other migratory fish in the Feather River system that will be considered include:

- Potential for placement of sturgeon in Lake Oroville or the Diversion Pool.

Species-specific review and compilation of information necessary to complete this task will be obtained from other Oroville Facilities FERC Relicensing Project study plans including SP-F3.2 for sturgeon from SP-F10 for steelhead and chinook salmon and will address relevant topics relating to life history and habitat requirements for juvenile and adult fish. Given the potential for numerous other species of fish to move up- and downstream within the river, all fish species that are known to occur within the Feather River will be identified from the species lists developed in SP-F3.2 and SP-F10 since additional non-targeted species most likely will be encountered during the collection and sorting operations.

Much of this information will be compiled as part of SP-F10, additional information specifically related to the conditions required for the successful passage of anadromous salmonids to and from reservoirs will be collected under this study plan, as needed. This effort will include collection and compilation of information on the habitat requirements for chinook salmon and steelhead. A description of the information obtained from SP-F10 and that is collected specific to reservoir passage will be included in draft form. Similar information for sturgeon will be obtained from SP-F3.2. Additional information on sturgeon management and the likelihood of developing a successful sturgeon management plan in Lake Oroville will be obtained from SP-F3.1. The following topics will be included in the review and description:

- Adult upstream migration requirements (timing, and prevalent water temperature and flow conditions);
- Adult holding habitat (habitat availability, water temperature, holding pool or stream characteristics);
- Spawning (habitat availability and suitability, abundance and distribution, timing, and factors affecting timing and success such as substrate conditions and water temperatures);
- Early development (factors affecting embryo incubation survival through emergence);
- Juvenile rearing (habitat availability and utilization, distribution and abundance, water temperature, substrate characteristics, refuges, shade, cover, food availability);
- Juvenile outmigration and movements (timing, prevalent flow, water temperature and other abiotic conditions); and
- Adult outmigration for steelhead and sturgeon (timing, prevalent flow, water temperature and other abiotic conditions).

Each species-specific review and compilation of information will address the topics identified above taking into consideration the characteristics innate to each of the target species. Task 1 will involve a literature review to provide the following four species-specific descriptions and an overview of all other species found in the Feather River:

- Summarize life history and habitat requirements of spring-run chinook salmon, fall-run chinook salmon, steelhead and sturgeon;
- Develop a species list of all other fish that are present in the lower Feather River.

Task 2: Inventory of Potentially Available Habitat for Juvenile and Adult Fish Upstream of Lake Oroville.

Introduction: Prior to determining the feasibility of fish passage alternatives, it is essential to estimate which areas upstream of the Oroville facilities would provide suitable habitat to meet the biological, hydrologic and physical habitat requirements of both juvenile and adult fish. Areas above Oroville Dam that historically and/or currently provide suitable habitat for spawning, rearing and holding activities will be identified to provide an estimate of both the amount and quality of upstream habitat that is available and the likelihood that the habitat could support sustainable fish populations. Once this has been achieved, the geographic extent of historical and currently available habitat will be used in conjunction with other determining factors (e.g. site access, potential methods and/or passage devices, operational and maintenance costs, etc.) to assess the potential for fish transport and release into these areas and the expected degree of success under various parameters and conditions (Task 4). ~~Habitat quantity and quality information will be variable and as a result, the synthesis and utilization of information will need to reflect the limitations of available information.~~

The historical extent of the naturally spawning fish populations that existed prior to implementation of upstream hydroelectric projects, diversion projects and the construction of Oroville Dam will provide a general estimate of the total ~~the~~ amount of potential spawning and rearing habitat that is available above the Oroville Facilities and could be utilized for potential PM&Es. However, for the purposes of this study (SP-F15) the geographic scope has been limited to the area below the first migration barrier above Lake Oroville. Any findings relating to the historical extent of anadromous salmonid spawning habitat that extends beyond this point will be used in ~~SP-F15C~~the cumulative effects analysis.

Existing habitat conditions in the upstream tributaries below the first migration barrier above Lake Oroville will be described according to the identified geographical units provided in Section 5.0 under the General Approach. The review and discussion will address such topics as water temperature, flow regimes, water quality, instream cover, mesohabitat and substrate quality (i.e. gravels) and the level of analysis will vary depending upon the quality of data that is available. This task will rely upon habitat information gathered in Task 4 of SP-G1 and Task 1C of SP-F3.1, to characterize fish habitat in Lake Oroville's upstream tributaries extending from the lake's high water mark to the first upstream migration barrier. SP-G1 will measure changes in the geomorphic characteristics including water depth, stream velocity, bed-load transport, temperature and other stream parameters as necessary. Several representative cross-sectional areas will be identified and used to measure these parameters during a range of flows and at topographic breakpoints. Habitat components from SP-F3.1 that will identify fish habitat below the first migration barrier above Lake Oroville include:

- Mesohabitat maps provided by SP-G1;
- Substrate characterization, transect data, channel morphology, assessment of woody debris, and cover cross-sectional monitoring data including water depth, velocity, and turbidity obtained from SP-G1;
- Inundation flow boundaries at various flow levels interpolated from SP-G1 channel transects;
- Vegetation survey results (grass, shrub, bush, tree classes) obtained from SP-T4;
- Data from SP-G1 used in the analysis of passability of sediment plugs within the fluctuation zone of Lake Oroville;
- Water temperature data obtained from SP-W6;
- Water quality data obtained from SP-W1; and

- Exceedances of water quality recommendations for freshwater aquatic life obtained from SP-W1.

Habitat maps developed in SP-F3.1 will also be used to describe the existing conditions in the upstream tributaries of 2nd order or higher. In SP-F3.1, GIS coverages of habitat components were developed to estimate the location, extent and relative qualities of habitat. Information relating to specific habitat components that were integrated into the GIS database and output maps from SP-F3.1 will also be used in SP-F15 to provide a quantitative estimate of potentially suitable spawning riffles and pool habitats that could be used for spawning and rearing activities by juvenile and adult fish in Lake Oroville's upstream tributaries below the first migration barrier. Aquatic habitat within Lake Oroville, the Diversion Pool, the Fish Barrier Pool and the Thermalito complex may also have the potential for supporting one or more life stages of the anadromous and migratory species targeted in SP-F15 for providing passage beyond the Fish Barrier Dam. Lentic elements pertaining to these water bodies and their potential for providing spawning, rearing and holding habitat will be considered during the literature review. Several of the components to be evaluated include, but are not limited to, the following: lake topography, annual lake water level cycles, temperature profiles, annual variations in water quality, information on fish and invertebrate species present in the lake, including discussion of common ecological interrelationships. Information regarding the existing habitat conditions at the Oroville Facilities will be obtained from SP-F3.1 and SP-F3.2. Habitat components in these water bodies will be obtained primarily from SP-F3.2 and included in an analysis that is similar to what was described for the upstream tributaries, using information gathered in SP-F3.1. GIS coverages of habitat components will be developed to estimate the location, extent and relative qualities of habitat by species by lifestage. Habitat locations will be determined by combining the habitat component coverage to identify areas with combinations of habitat characteristics that fit the profile of each fish's habitat preferences. Habitat components to be combined to identify fish habitat include:

- Mesohabitat maps (existing maps require registration and digitizing);
- Substrate characterization, transect data, channel morphology, assessment of woody debris, and cover cross-sectional monitoring data including water depth, velocity, and turbidity obtained from SP-G2;
- Inundation flow boundaries at various flow levels interpolated from SP-G2 channel transects;
- Vegetation survey results (grass, shrub, bush, tree classes) obtained from SP-T4;
- Water temperature data including water temperature measurements to the confluence of the Sacramento and Feather rivers in both riffles and deep pools obtained from SP-W6;
- Water quality data including turbidity and dissolved oxygen measurements obtained from SP-W1;
- Exceedances of water quality recommendations for freshwater aquatic life obtained from SP-W1;
- Macroinvertebrate community characteristics obtained from SP-F1; and
- Flow data obtained from USGS gaging stations.

In order to achieve task objectives including describing and characterizing the extent of historical spawning habitat and existing habitat conditions, this task will consist of a review of available data and reports on physical, hydrological and operational characteristics of the project facilities for the area located between the Fish Barrier Dam and the first migration barrier above Lake Oroville. Information sources may include, but are not limited to, the following:

- California Department of Fish and Game (DFG) Fish Bulletin 179: Contributions to the Biology of Central Valley Salmonids 2001.
- California Department of Fish and Game Report: Fisheries problems of the Feather River with special reference to the proposed Oroville Dam. October 30, 1952.
- Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. Sierra Nevada Ecosystem Project: Final Report to Congress (Yoshiyama et al. 1996).
- GIS layer corresponding to the Final Report to Congress (source: Yoshiyama 1996?).
- SP-F3.1, Evaluation of Project Effects on Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area.
- SP-F3.2, Evaluation of Project Effects on Non-salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam.
- SP-F8, Transfer of Energy and Nutrients by Anadromous Fish Migrations.
- Literature, file reports, memoranda or notes that document present use of tributaries upstream of Lake Oroville by introduced anadromous fish.

Habitat information and distribution ranges obtained from sources of both historical and existing habitat will be synthesized and integrated into a spatial database that will be used to develop a GIS coverage and will form part of the task deliverable. Task 2 deliverables will include:

- Literature review of all available information including survey data, reports, maps, scientific articles, information provided in other study plans, etc. to identify the geographic range of historical fish distribution, estimated quantity and quality of available rearing and spawning habitat for each individual upstream tributary reach above Oroville Dam. Primary informational sources for this task will come from the historical extent of fish distribution (DFG 2001) and habitat data collected from SP-F3.1.

- A set of maps composed of the following information:
    - The historical extent of anadromous salmonid spawning habitat;
    - Facilities will be color coded by ownership;
    - Adjacent/Surrounding Land Ownership;
    - Existing natural and constructed fish barriers;
    - Each reach will be coded according to the quantity and quality of habitat. This may be very simplistic and general (e.g. miles of stream with suitable habitat), depending upon the amount of available information; and
    - Roads and Railroads (for access issues).

Task 3: Evaluation of methods and devices used in the capture, sorting, holding, transport and release of fish.

The objective of this task is to develop information regarding the ability to move anadromous salmonids and other targeted migratory fish (sturgeon) past the Oroville Facilities. It is essential to have a firm understanding

of the practicalities (e.g. mechanical capabilities, physical habitat requirements, estimated costs associated with implementation, operation and maintenance, etc.) associated with each device alternative that is under consideration. In addition to permanent structures and tested methodologies, this task will also consider and review devices and methodologies that are temporary and/or experimental in nature. The experiences and knowledge gained at other dams that have attempted the construction, implementation and operation of fish passage devices and fish capture, sorting, transport and release methods will also be reviewed under each subtask under Task 3.

Passage considerations for the study area beginning in the Feather River below the Fish Barrier Dam and extending into the Feather River upstream tributaries above Lake Oroville will encompass five discrete steps (capture, sorting, holding, transport and release) to be applied to fish moving both upstream and downstream in the system. Each of these steps will involve a review of all alternative methods and devices that could potentially be employed as a means of increasing fish passage. These alternative mechanisms will fall into one or more of the following categories: (a) capture of fish (adults) in the Feather River downstream of the Fish Barrier Dam; (b) sorting of fish (adults and juveniles of target and non-target species) below the Fish Barrier Dam; (c) holding sorted fish below the Fish Barrier Dam; (d) transport of adult fish from the sorting facility to the release destination; (e) release of fish (adults) into the designated water body; (f) capture of adults (species dependent) and juvenile fish; (g) sorting of captured fish (adults and juveniles of target and non-target species); (h) holding sorted fish prior to downstream transport; (i) transport of fish (juveniles and adults of some species) downstream to below the Fish Barrier Dam; (j) release of fish below the Fish Barrier Dam.

For each device, a thorough desktop evaluation/literature review will be performed that will identify, review, evaluate and synthesize information including, but not limited to: physical requirements necessary for each mechanism's installation, operation and maintenance, device efficiency and life span, operating capacities, costs associated with installation, operation and maintenance, performance standards regarding success/loss rates, potential impacts associated with device malfunction, limitations, compliance with NMFS device criteria, etc. The review will also be comprised of a description of known case studies and/or projects where the device has previously been used, coupled with a brief discussion on the level of success that was achieved following implementation of the device or methodology.

The experiences and knowledge gained at other dams that have attempted the construction, implementation and operation of passage devices and fish capture, sorting, transport and release methods for adult and juvenile fish will also be reviewed in each subtask under Task 3. The similarities of those dams with Oroville Facility dams will be recorded to assess the applicability of those experiences to this study. Many dams that have attempted the construction and operation of fish passage devices and fish transport methods are in river basins outside of California including, for example, Priest Rapids, Rocky Reach and McNary dams on the Columbia River, Lower Monumental and Little Goose dams on the Snake River, and Pelton Dam on the Deschutes River. Review of the experiences at California Central Valley dams and other dams similar to the Oroville Facility dams that have implemented passage or transport systems for adult salmonids should provide insights into the potential for constructing and operating successful fish ladders, bypass channels and other fish passage devices or transport programs in the study area. Contingent on the available information, the

review, to be performed by incremental spatial movements upstream (adult fish) and downstream (juvenile and adult fish), under this task will involve the following activities:

- Inventory, document, and synthesize descriptions of California Central Valley dams with passage or transport systems. The inventory of dams will be ordered by passage or transport system, degree of similarity with Oroville Facility dams, and degree of success. Success criteria, as reported in the literature, also will be described. Applicability to the Oroville Facility dams of the main characteristics associated with each facility included in the review will be provided;
- Inventory of dams with passage or transport system in other river basins. As for the Central Valley dams, information will be ordered by passage or transport system, degree of similarity with Oroville Facility dams, and degree of success (as reported in the literature). Applicability to the Oroville Facility dams of the main characteristics associated with each facility will be provided;
- Synthesis and description of available information regarding the extent of predation on juvenile salmonids, and the physical environments associated with dam passage infrastructure and configurations. Considerations will include structures such as passage intakes, outfalls, diversion canals, and juvenile bypass structures;
- Evaluation of the operation and maintenance of fish ladders (e.g., regular monitoring and adjustment of ladders to maintain optimal flow through ladders, and flow rates for effective ladder operation);
- Evaluation of dam-related delays of upstream migration of adult salmon and steelhead, and migratory fish including problems adult fish may have in locating and ascending ladders (e.g., spillway configuration and location of downstream entrance to ladders, attraction flows, fallback, etc.);
- Screening; and
- General comparison of the relative success of adult and juvenile passage structures (e.g., fish ladders, elevators, juvenile bypass systems) and transportation methods (e.g., adult trap-and-truck, juvenile trap-and-truck).

For each of the device categories associated with upstream and downstream movement and passage of fish, Task 3 will also review, by subtask, any literature or experimental studies that investigate fish behavior by target species at dams or barriers where adult and juvenile bypass systems, fish ladders, and other evaluated devices are present. The review of these studies will help to evaluate the feasibility of alternative methods for passing and transporting adult and juvenile salmonids past Oroville Facility dams because they will provide insight on the potential success of each method, based on the species' behavioral responses and survival. For example, a particular juvenile bypass system might constitute an adequate passage alternative for juvenile chinook salmon, but not for steelhead, because juvenile chinook salmon may tend to find and pass the bypass more easily, faster and in greater numbers than steelhead juveniles.

Many of the studies that involve tagging of adult or juvenile salmonids have been designed to evaluate issues such as routes used by juveniles and adult salmonids approaching dams with fish passage devices (i.e., longitudinal, latitudinal and depth positioning of fish attempting passage with respect to the passage device). These studies also evaluate responses to attraction flows and guidance devices, passage times, probability of passing through the passage device as opposed to other alternative passage routes (e.g., spillway, turbine intake) and probability of the fish falling back. Adult salmonids often pass upstream through the fish ladder and fall back via the spill, the juvenile bypass, or the turbines. If they have not been seriously harmed by the

fallback they reascend the ladder. Many tagging experiments also have evaluated and contrasted the survival of fish that pass a dam through different passage routes (e.g., spillway, juvenile bypass and turbines) or have been transported by truck or barge for various salmonid species. Contingent on the information available, this review will include the following topics for sturgeon and each of the target salmonid species:

- Routing considerations for adult fish approaching dams with fish ladders;
- Routing considerations for juvenile fish approaching dams with juvenile bypass systems;
- Species response to attraction flows, water turbulence and temperature;
- Species reaction to guidance devices (e.g., screens, surface flow deflectors);
- Estimates of residence and passing times;
- Probability of fall-back;
- Survival associated with passing through by-pass systems, spills and turbines;
- Survival associated with trap-and-trucking; and
- Survival associated with trap-and-barging.

Many of the individual device alternatives that could be used for one step, or passage category, in the process could also be applied to other steps or may be directly or indirectly influential upon the capabilities or limitations of another device alternative, or of a particular species of fish. Each subtask will try to provide as much information as possible regarding the physical, biological, hydrologic, and economic elements associated with each device in order to identify those relationships and interdependencies. During the review, discussion and evaluation of each subtask listed below, the study will consider all of the aforementioned topics (i.e. physical design considerations, case studies from other projects, fish behavior according to device relevance), taking into consideration each of the bulleted items specified in the preceding introductory discussion.

The subtasks are presented below according to anticipated steps and probable locations as they would incrementally occur within the system, beginning in the lower river reaches and moving upstream past the Oroville facilities and into the tributaries above Lake Oroville. It should be noted that this approach was taken solely because it seemed to be the most logical, given the complexity of the multiple passage categories involved and the numerous device considerations and potential configurations. However, it should be noted that the sequential order, as presented in Task 3, does not imply that further evaluation (Task 4) or actual implementation would have to follow a similar organizational arrangement.

Task 3A: Device alternatives for the capture of fish (adults) in the river downstream of the Fish Barrier Dam.

This subtask will identify and review known devices and methodologies that can be used to capture adult fish in the downstream reaches of the Feather River, according to the elements described in the introductory discussion to Task 3. Instances where specific devices have previously been employed on other projects or facilities similar to Oroville will also be summarized. Fish capture device alternatives that will be reviewed include, but are not limited to, the following mechanisms:

- Fish ladder at the Feather River Hatchery;

- Removable weir in the river;
- Crowding devices, or trap and lift mechanisms;
- Use of a lock to first capture fish followed by transporting them over the dam with an elevator;
- Conveyors;
- Alaskan Weir;
- Drum Screen;
- Louvers.

Task 3B: Device alternatives for sorting of fish below the Fish Barrier Dam.

There are several components that must be considered to complete this subtask. The first component evaluates whether a sorting facility is necessary. As a part of making that determination, there are several factors pertaining to this topic that must be examined. Capture devices will indiscriminately collect any and all species that are moving upstream in the Feather River. This includes non-targeted species such as pikeminnow, hardhead, and hitch, among others. Potential risks associated with not sorting these fish out of the groups to be moved upstream include, but are not limited to: introducing and spreading disease, predation, competition for resources such as food, cover and spawning habitat, genetic introgression, and other risks associated with introducing non-native species into upstream habitats. Additionally, as a part of this task, there needs to be some determination as to which entity or group of entities will be responsible for determining which species are to be transported past the existing migration barriers. A review of existing literature will provide information regarding (a) potentially beneficial and adverse impacts associated with transporting all individuals, regardless of species and life history, that were caught by the capture device as well as (b) potentially beneficial and adverse impacts associated with employing a sorting mechanism which would allow only preferential species and/or select sizes of fish to be transported upstream. The findings of the literature review will provide rationale to support a decision of whether or not a sorting facility would be necessary, desirable or beneficial.

This subtask will also identify and review known devices and methodologies that can be used to sort the various species and sizes of fish that are known to inhabit the downstream reaches of the Feather River, according to the elements described in the introductory discussion to Task 3. Instances where specific devices have previously been employed on other projects or facilities similar to Oroville will also be summarized according to the introductory discussion to Task 3. Fish sorting device alternatives that will be reviewed include, but are not limited to, the following mechanisms:

- Gated structures; and
- Computer regulated systems.

Task 3C: Device alternatives for holding fish below the Fish Barrier Dam.

This subtask will identify, review and summarize information relating to known devices and methodologies that can be used to hold targeted fish once they have been sorted in the downstream reaches of the Feather

River, according to the elements described in the introductory discussion to Task 3. Additional factors to be evaluated include but are not limited to: relative device specific holding times, and flow requirements. Instances where specific devices have previously been employed on other projects or facilities similar to Oroville will also be evaluated and summarized according to the introductory discussion to Task 3. Fish holding device alternatives and methodologies that will be reviewed include, but are not limited to, the following mechanisms:

- Tanks;
- Raceways; and
- Instream pens or cages.

Task 3D: Device alternatives for transport of adult fish from the sorting facility into the upstream tributaries below the first migration barrier above Lake Oroville.

This subtask will identify, review and summarize information relating to known devices and methodologies that can be used to transport targeted fish once they have been sorted in the downstream reaches of the Feather River, according to the elements described in the introductory discussion to Task 3. Factors to consider include but are not limited to: the method of transfer, the location of fish release, and length of time the fish would be in transit.
Instances where specific devices have previously been employed on other projects or facilities similar to Oroville will also be evaluated and summarized according to the introductory discussion to Task 3. Fish transport device alternatives and methodologies that will be reviewed include, but are not limited to, the following mechanisms:

- Trap and elevator/trolley (over the dam only);
- Trap and truck fish to upstream sites;
- Trap and rail fish to upstream sites; and
- Trap and barge.

Task 3E: Device alternatives for the release of fish (adults) into Lake Oroville and the upstream tributaries below the first migration barrier above Lake Oroville.

This subtask will identify, review and summarize information relating to known devices and methodologies that can be used to release adult fish once they have been transported upstream, according to the elements described in the introductory discussion to Task 3. Instances where specific devices have previously been employed on other projects or facilities similar to Oroville will also be evaluated and summarized according to the introductory discussion to Task 3.

Task 3F: Device alternatives for the capture of adults (species dependent) and juvenile fish in the upstream tributaries below the first migration barrier above Lake Oroville.

This subtask will identify, review and summarize information relating to known devices and methodologies that can be used to capture adult and juvenile fish in the upstream tributaries, according to the elements described in the introductory discussion to Task 3. Instances where specific devices have previously been employed on other projects or facilities similar to Oroville will also be evaluated and summarized according to the introductory discussion to Task 3. Fish capture device alternatives and methodologies that will be reviewed include, but are not limited to, the following mechanisms:

- Drum Screen;
- Louvers;
- Eicher Screens;
- Flat Plate Screens;
- Gulper;
- Fish Ladders; and
- Removable Weirs.

Task 3G: Device alternatives for sorting of fish captured in the upstream tributaries below the first migration barrier above Lake Oroville.

This subtask will identify, review and summarize information relating to known devices and methodologies that can be used to sort adult and juvenile fish in the upstream tributaries below the first migration barrier above Lake Oroville, according to the elements described in the introductory discussion to Task 3. Instances where specific devices have previously been employed on other projects or facilities similar to Oroville will also be evaluated and summarized according to the introductory discussion to Task 3. Fish sorting device alternatives and methodologies that will be reviewed include, but are not limited to, the following mechanisms:

- Gated structures; and
- Computer regulated systems.

Task 3H: Device alternatives for holding fish in the upstream tributaries below the first migration barrier above Lake Oroville, prior to transport.

This subtask will identify, review and summarize information relating to known devices and methodologies that can be used to hold targeted fish once they have been sorted in the upstream reaches of the Feather River, according to the elements described in the introductory discussion to Task 3. Additional factors to be evaluated include but are not limited to: relative device specific holding times, and flow requirements. Instances where specific devices have previously been employed on other projects or facilities similar to Oroville will also be evaluated and summarized according to the introductory discussion to Task 3. Fish holding device alternatives and methodologies that will be reviewed include, but are not limited to, the following mechanisms:

- Tanks;
- Raceways; and
- Instream pens or cages.

Task 3I: Device alternatives for the transport of juvenile salmonids and adults (steelhead that do not expire after spawning, and sturgeon) from the upstream tributaries below the first migration barrier above Lake Oroville into the Feather River below the Fish Barrier Dam.

This subtask will identify, review and summarize information relating to known devices and methodologies that can be used to transport targeted fish into the downstream reaches of the Feather River from the upstream tributaries above Lake Oroville, according to the elements described in the introductory discussion to Task 3. Factors to consider include but are not limited to: the method of transfer, downstream release locations, spatial and temporal variations in transport, (e.g. adults are released at one point while juveniles are transported to another). Instances where specific devices have previously been employed on other projects or facilities similar to Oroville will also be evaluated and summarized according to the introductory discussion to Task 3. Fish transport device alternatives and methodologies that will be reviewed include, but are not limited to, the following mechanisms:

- Trap and elevator/trolley (over the dam only);
- Trap and truck fish to upstream sites;
- Trap and rail fish to upstream sites; and
- Trap and barge.

Task 3J: Device alternatives for the release of fish below the Fish Barrier Dam.

This subtask will identify, review and summarize information relating to known devices and methodologies that can be used to release adult and juvenile fish once they have been transported downstream, according to the elements described in the introductory discussion to Task 3. Instances where specific devices have previously been employed on other projects or facilities similar to Oroville will also be evaluated and summarized according to the introductory discussion to Task 3.

Task 3 deliverables will include:

For each subtask, a thorough literature review will be conducted to inventory, describe and evaluate the parameters of each device alternative and its potential applicability for providing fish passage in the study area. Information regarding adult and juvenile habitat requirements of fish by species, susceptibility of fish by species and life stage to various capture conditions, predation risks, etc. will be compiled. Where available, the summary narrative will also review and discuss other projects where the device has been implemented and the level of success that was achieved. See Section 6.0, Results and Projects/Deliverables for a task-specific deliverables list.

Task 4: Development of weighted matrix and GIS decision support tool.

Evaluation of the feasibility of providing anadromous and migratory fish passage over, around or through Oroville Facility dams must include an evaluation of the merits, relative to the existing condition, of reintroducing fish to the upper tributaries of the Feather River. An important part of this evaluation consists of an assessment of the potential for passing anadromous fish into the upstream tributaries below the first migration barrier above Lake Oroville and for passing migratory fish into Lake Oroville, the Fish Barrier Pool and the Thermalito Diversion Pool. If upstream passage results in significant losses of salmon production, this provision of upstream passage would be characterized as detrimental, with respect to current Feather River salmon production.

Information obtained in Tasks 1, 2, and 3 will be incorporated into a GIS-based decision support tool which will be used as a means of assessment to evaluate each potential reach specific alternative action which could be implemented as a means of improving fish production and providing passage into the upper tributaries of the Feather River, above Lake Oroville. This tool will allow decision makers to evaluate all possible combinations of each method and device used for upstream and downstream fish capture, sorting, holding, transport and release for each tributary under a variety of weighted habitat, site access, risk and cost considerations.

Task 4A: Description of facility structures and physical conditions as related to the feasibility of fish passage.

There are several facility structures located between the Feather River Fish Barrier Dam and the first upstream migration barriers above Lake Oroville. The Fish Barrier Dam, located upstream of the Feather River Hatchery and approximately five miles below Oroville Dam, diverts fish into a fish ladder that leads to the hatchery. The dam is 91 feet high, and the crest elevation and length are 181 feet and 600 feet, respectively. The Thermalito Diversion Dam is located approximately four miles downstream of Oroville Dam. The Thermalito Diversion Dam has a height of 143 feet, a crest length of 1,300 feet and an elevation of 233 feet. Oroville Dam is the highest earthfill dam in the United States. It is 770 feet high, with a dam crest of 6,920 feet long and 51 feet wide.

The following list is a compilation of the distinct geographic units that contain facility structures and existing barriers within the study area:

- Below the Fish Barrier Dam
- Fish Barrier Pool
- Diversion Pool
- Lake Oroville above the dam
- Any location downstream where smolts may be placed

This task will provide succinct narratives, by geographic unit, detailing the description and characteristics (e.g. dimensions, hydraulics, present operational, functional and physical conditions) of each facility structure

that is present on the major tributaries within the study area. It will include review of aerial photographs, topographic maps, and data and reports on physical, hydrological, hydraulic and operational characteristics of the Fish Barrier Dam, Thermalito Diversion Dam, Oroville Dam and Lake Oroville, as information is available. The following activities will be included in this subtask:

Describe the Features and Characteristics of the Fish Barrier Dam:

- Review of available aerial photographs and topographic maps of the area occupied by the Fish Barrier Dam and the Thermalito Diversion Dam.
- Review plans, specifications and designs for the Fish Barrier Dam and Thermalito Diversion Dam areas and cross-sections of the dam structures; and
- Review available studies on flow dynamics in the areas immediately above and below the Fish Barrier Dam and at the base of the spillways during normal project operations.

Describe Features and Characteristics of the Thermalito Diversion Dam:

- Review of available aerial photographs and topographic maps of the area occupied by the Thermalito Diversion Dam.
- Review plans, specifications and designs for the Thermalito Diversion Dam areas and cross-sections of the dam structures; and
- Review available studies on flow dynamics in the areas immediately above and below the Thermalito Diversion Dam and at the base of the spillways during normal project operations.

Describe Features and Characteristics of Oroville Dam:

- Review of available aerial photographs and topographic maps of the area occupied by Oroville Dam;
- Review, document, describe and synthesize data and reports on the annual cycle of Lake Oroville water levels, describing monthly and inter-annual variation;
- Review, document, describe and synthesize data and reports regarding water temperature profiles throughout the year in the area immediately above Oroville Dam;
- Review plans, specifications and designs for the Oroville Dam area and cross-section of the dam structure; and
- Review available studies on flow dynamics in the area immediately above Oroville Dam and at the base of the spillway during normal project operations.

Task 4B: Development of a weighted matrix to assign a ranking of feasibility for each alternative.

The first part of this evaluation will draw upon the factual device-specific information that was obtained in Task 3 for each aspect of upstream and downstream fish passage (i.e. capture, sorting, holding, transport and release). The device summaries (Task 3) relating to the five steps listed above will be applied to individual site conditions, species-specific life history and habitat requirements at each of the partitioned study areas including the Fish Barrier Pool, the Diversion Pool, the upstream tributaries below the first migration barrier above Lake Oroville, etc. Additionally, this task would compare the device-specific information obtained from Task 3 to published adult and juvenile mortality information (e.g. sources, mortality rates, pre-spawning mortality considerations) that is described in Task 1A in order to get an indication of potential mortality

expectations associated with each passage configuration. The site potential of each device will be ascertained by evaluating how suitable a given device would be under reach-specific conditions and as appropriate for targeted fish species in each segment of the geographic area.

For each device, a brief explanation of how the device would be expected to function in a particular reach will develop the rationale that will allow for the device to be rated according to its site potential, desirability and conformance with management objectives, expected success rate, and the anticipated feasibility of employing the device at that particular location. These ranked values will then be carried over into the weighted matrix for comparison against other critical factors such as site access, cost, risk potential and system loss.

As part of the final product, a weighted matrix will be constructed to provide a visual representation of all weighted factors (accessibility, habitat, barriers, costs), the descriptive summaries of each location and the potential methods and mechanisms of fish passage for each tributary. The end result, or product, of the matrix will essentially be a feasibility ranking profile of each alternative given certain agreed upon parameters and conditions, ultimately to be identified by the project's decision making entities. The matrix will be designed to allow the decision makers to alter the relative importance of any particular element, as a means of providing greater flexibility in the evaluation and decision making process. Factors that will be considered and integrated into the design of the weighted matrix include:

Physical/mechanical considerations:

1. Location;
2. Upstream capture devices;
3. Downstream capture devices;
4. Upstream sorting devices;
5. Downstream sorting devices;
6. Downstream holding devices;
7. Upstream holding devices;
8. Upstream transport devices;
9. Downstream transport devices;
10. Upstream release devices;
11. Downstream release devices;
12. Site access;
13. Costs (installation/operation/maintenance);

Biological/ecosystem considerations:

14. Habitat quantity and quality;
15. Predation risks during capture, sorting, holding, transport and release of juveniles and adults:
    - System loss from predation at each aspect (e.g. capture, sorting, holding, transport and release) as well as incremental losses throughout the system;
    - Post-introduction - There may be a need to vary the release points and timing because some predators will just wait for released fish;
    - Potential impacts on resident species (fish, amphibians, etc.) that may be present in the upstream tributaries);

16. Identification of potential risks associated with the movement and increased passage of migratory and anadromous fish;
17. Listing of considerations and potential problems that may arise as a result of introducing fish into areas where either historic and/or current access to available spawning and rearing habitat has been limited or nonexistent;
18. ESA issues (e.g. If there are red-legged frogs in one tributary, consider the risk of predation on tadpoles by juvenile salmonids.)
~~18.~~19. Potential problems or risks that might arise if the fish are not sorted prior to introduction and/or are put into new areas:
    - Risk of putting non-native species upstream;
    - Disease;
    - ~~Genetic Introgression/~~Hybridization;
    - Competition for resources such as food, cover, spawning habitat;
    - Nutrient transfer;
    - Evaluation of residualization potential of juvenile salmonids in Lake Oroville (i.e. the fish take up residence within the lake);
    - ~~Balance potential benefits against potential losses; and~~
    - ~~ESA issues (e.g. If there are red-legged frogs in one tributary, consider the risk of predation on tadpoles by juvenile salmonids.)~~
20. Potential benefits (include but not limited to)
    - Increased range for targeted species;
    - Improved genetic diversity and spatial segregation;
    - Increased abundance of non-hatchery fish;
    - Nutrient transfer;
21. Effectiveness or efficiency of passage alternatives.

Within the matrix, two individual ranks will be assigned to each alternative. The first ranked score will be the result of an assessment of the desired device(s), biological and physical conditions and interactions that are present within a given tributary or reach. The second ranked score will incorporate the estimated costs associated with installation, operation and maintenance of each fish passage alternative. Scores will be unit-less in value so as to provide an unbiased and meaningful comparison index for all conditions and to avoid introducing unnecessary or sensitive assumptions into the evaluation. These values will then be carried forward and applied to Task 4C.

The sample matrix on the following page serves as a conceptual framework for the structural design of the matrix in Task 4B and illustrates the major components that will be used to evaluate potential passage alternatives within this subtask. Ideally, all of the elements listed under the aforementioned headings of *physical/mechanical considerations* and *biological/ecological considerations* will be incorporated into the final matrix. Because the matrix on the following page is only intended to provide a visual representation of the elements that will be used is this evaluation process, it only includes a few of the numerous elements under consideration. It should be noted that the final product will be much more comprehensive and extensive in length than what is displayed below.

Location	Capture Devices										Sorting Devices				Holding Devices			Transport Devices					Release Devices		Behavioral Devices					Temporary Devices				Experimental Devices			Risks						Habitat			Access	Rank 1	Cost			Rank 2
	Fish ladder at hatchery	Removable Weir	Fish Lock	Alaskan Weir	Drum Screen	Wedge-weir Screens	Eicher Screen	Flat Plate Screens	Gulper	Other	Computer Regulated System	Sorting Gates	Sorting Flume	Other	Tanks	Raceways	Other	Trap and Truck	Trap and Barge	Trap and Rail	Trap & Elevator/Trolley	Other	Pipes	Other	Electrical	Acoustic	Lights	Louvers	Other				Other			Other	Predation	Pathogens/Disease	Resource Competition	Stress/Mortality	Genetic introgression	Other	Spawning	Rearing	Holding		Biological Evaluation	Installation	Operation	Maintenance	
Below the Fish Barrier Dam																																																
Fish Barrier Pool																																																
Diversion Pool																																																
Lake Oroville above the Dam																																																
West Branch of the North Fork																																																
North Fork Feather River																																																
Middle Fork Feather River																																																
South Fork Feather River																																																

Task 4C: Development of a GIS-derived decision support tool.

Passage feasibility (e.g. likely to be feasible, potentially feasible, not likely to be feasible) for each alternative or combination thereof, will be assessed once the physical and biological requirements (Task 4B) of the alternatives have been determined by assigning a rank based upon the site requirements of each device, costs, required maintenance, etc. The GIS derived decision support tool, in combination with the set of maps from Task 2 and the feasibility matrix (Task 4B) will be designed to utilize a "tiered" approach regarding the analysis of potential fish passage options. Initial evaluation of a certain operational scenario will be quite generalized, with each subsequent level (or tier) of analysis becoming subject to a more rigorous set of conditions which must be met in order for a given scenario to progress to the next phase of analysis. This approach is intended to direct the focus of the analysis forward in an organized manner, eventually leading towards identification of the alternatives with the highest priority, best value and greatest potential benefits.

The decision support tool will facilitate a broad level analysis of each potential alternative by integrating the physical/mechanical and the biological/ecosystem considerations from Task 4B, the mapping results from Task 2 and the following more subjective but none the less important topics of evaluation, including:

- Direct and incremental system losses;
- Cost (the total number of fish per dollar);
- Engineering feasibility; and
- Potential levels of risk associated with each phase.

The objective of the decision support tool is to evaluate the feasibility of each passage alternative under a wide range of potential logistical and operational circumstances. While it is not practical to describe each of the potential compilations that the tool will be able to evaluate, the following hypothetical example is intended to describe the manner in which the tool has been envisioned to function. For instance, as part of the evaluation process, project decision makers decide to investigate the feasibility of using device "x" at potential locations 1, 2, and 3 with target species "a". After review of the physical/mechanical and biological/ecological considerations found in the matrix (Task 4B), it is determined that the life history and habitat requirement of species "a" are very suitable to the existing habitat conditions at locations 2 and 3. However, the physical site conditions at locations 2 and 3 would not support the operational requirements of device "x" and there would be a high risk of failure of using this device at these locations. Evaluation of another device, "y" at location 2 indicates that nearly all factors (cost, access, operational capacity, low rates of fish mortality, etc.) appear favorable and would be expected to lead to successful fish passage. Changing the evaluation to consider device "y" in the decision support tool would yield a passage determination of "highly feasible". Therefore, as a result of evaluating all possible alternatives, the reviewers decide the device "y" would be the best choice to use at location 2 if they want to provide passage to species "a".

The decision support tool will have the option of altering one or more of the parameters in order to assess how a particular change would impact the overall feasibility of the desired action or combination of actions. Using the example provided above, suppose that it is determined that all of the consideration factors yield highly feasible scores supporting the use of device "y" at location 2 to provide passage to species "a", with the exception of poor site accessibility. Following further discussion, it becomes apparent that the reason for

poor site access is because the road was abandoned after a flood event. Altering the ranking for site access (i.e. if site access were improved) in the decision support tool indicates that this scenario would be highly feasible and would be a good option for long-term success. It is decided that if site access were improved, this alternative would have the highest level of overall success, compared to other potential alternatives. Based upon this information, the decision makers might decide to improve the road so that this alternative could be implemented.

The flexibility inherent to the decision support tool will allow for a very extensive range of alternatives to be evaluated. Depending upon the respective outcome under certain operational scenarios, the decision support tool could also provide comparison of multiple passage alternatives occurring across a range of temporal and spatial components. Additionally, it should be recognized that certain assumptions such as cost and numbers of fish are not clearly defined values. Using the decision support tool, the assumptions relating to these factors could be adjusted, within limits, to get a more representative range of values. However, the limitations of the tool should also be recognized. For instance, if the order of magnitude changes in the assumptions, then the usefulness of the model may be impaired.

In summary, Task 4 identifies and provides the building blocks and tools necessary to facilitate negotiation of PM&Es. These products include the following deliverables:

- Summary of facility structures and physical conditions by geographic unit (Task 4A);
- Develop a matrix of alternatives/locations and rationale narratives that will provide an indication of the gated process and explore the following issues (Task 4B):
    - For each phase in the analysis, list the alternative mechanisms;
    - A weighted description/evaluation of each mechanisms (based on the literature review) in order to determine some sort of ranking profile (i.e. highly feasible, potentially feasible, not feasible);
    - Identify possible options to modify the scores (i.e. if by changing one factor, the alternative would become feasible);
- GIS-derived decision support tool (Task 4C);

6.0 Results and Products/Deliverables

Results

Results will be organized following the task headings. Each task will include a narrative of the relevant findings as well as tables, figures and maps summarizing the key points. The anticipated maps, graphical representation of reviewed data (e.g., charts, and graphs), and summary figures and tables include:

- Summary of life history and habitat requirements for all targeted fish species (Task 1);
- Summary of historical and current habitat available for spawning and rearing (Task 2);
- Set of maps composed of the following information (Task 2):

- Historical spawning extent--- The extent of known historical spawning habitat will be determined through a review of existing literature in coordination with the cumulative effects analysis e.g. Yoshiyama et al, 2001.
- Facilities --- Color coded by ownership;
- Adjacent/Surrounding Land Ownership --- Will show which landowners/other entities might have concerns regarding fish transport/placement (e.g. City of Quincy).
- Existing Fish Barriers--- Natural and Constructed
- Code each reach with quantity and quality of habitat--- May be very simple and general (e.g. miles of stream with suitable habitat), depending upon the amount of available information
- Roads and Railroads (for access issues)

- Summary of methods and devices used for fish capture, sorting, holding, transport and release (Task 3) including:
  - Fish Capture (Tasks 3A and 3F)

    Inventory, document, describe and evaluate the following elements pertaining to each capture device: physical requirements necessary for each mechanism's installation, operation and maintenance, device efficiency and life span, pros and cons, operating capacities, costs associated with installation, operation and maintenance, performance standards regarding success/loss rates, potential impacts associated with device malfunction, maintenance requirements, limitations, compliance with NMFS device criteria, etc. Additionally, this product will include a summary and brief discussion, as appropriate, regarding other projects where such a device has been implemented and the level of success that was achieved.

    Information regarding adult and juvenile habitat requirements of fish by species, water temperature requirements of fish by species, spawning/rearing/holding habitat requirements, predation risks, susceptibility of each species to various capture conditions, and species response to stress and loss will be obtained from Task 1 and will used to evaluate species-specific considerations associated with various types of capture devices.

  - Fish Sorting (Task 3B and 3G)

    Inventory, document, describe and evaluate the following elements pertaining to each sorting device: physical habitat requirements necessary for each mechanism's installation, operation and maintenance, device efficiency and life span, pros and cons, operating capacities, costs associated with installation, operation and maintenance, performance standards regarding success/loss rates, potential impacts associated with device malfunction, maintenance requirements, limitations, compliance with NMFS device criteria, etc. Additionally, this product will include a summary and brief discussion, as appropriate, regarding other projects where such a device has been implemented and the level of success that was achieved.

    Information regarding adult and juvenile habitat requirements of fish by species, water temperature requirements of fish by species, spawning/rearing/holding habitat requirements, predation risks, susceptibility of each species to various capture conditions, and species response to stress and loss will be obtained from Task 1 and will used to evaluate species-specific considerations associated with each type of sorting facility.

- Fish Holding (Task 3C and 3H)
  Inventory, document, describe and evaluate the following elements pertaining to each holding device: physical habitat requirements necessary for each mechanism's installation, operation and maintenance, device efficiency and life span, pros and cons, operating capacities, costs associated with installation, operation and maintenance, performance standards regarding success/loss rates, potential impacts associated with device malfunction, maintenance requirements, limitations, compliance with NMFS device criteria, etc. Additionally, this product will include a summary and brief discussion, as appropriate, regarding other projects where such a device has been implemented and the level of success that was achieved.

  Information regarding adult and juvenile habitat requirements of fish by species, water temperature requirements of fish by species, spawning/rearing/holding habitat requirements, predation risks, susceptibility of each species to various capture conditions, and species response to stress and loss will be obtained from Task 1 and will used to evaluate species-specific components associated with each type of holding alternative.

- Fish Transport (Tasks 3D and 3I)
  Inventory, document, describe and evaluate the following elements pertaining to each transport device: physical habitat requirements necessary for each mechanism's installation, operation and maintenance, device efficiency and life span, pros and cons, operating capacities, costs associated with installation, operation and maintenance, performance standards regarding success/loss rates, potential impacts associated with device malfunction, maintenance requirements, limitations, compliance with NMFS device criteria, etc. Additionally, this product will include a summary and brief discussion, as appropriate, regarding other projects where such a device has been implemented and the level of success that was achieved.

  Information regarding adult and juvenile habitat requirements of fish by species, water temperature requirements of fish by species, spawning/rearing/holding habitat requirements, predation risks, susceptibility of each species to various capture conditions, and species response to stress and loss will be obtained from Task 1 and will used to evaluate species-specific components associated with each type of transport alternative.

- Fish Release (Tasks 3E and 3J)
  Inventory, document, describe and evaluate the following elements pertaining to each release device: physical habitat requirements necessary for each mechanism's installation, operation and maintenance, device efficiency and life span, pros and cons, operating capacities, costs associated with installation, operation and maintenance, performance standards regarding success/loss rates, potential impacts associated with device malfunction, maintenance requirements, limitations, compliance with NMFS device criteria, etc. Additionally, this product will include a summary and brief discussion, as appropriate, regarding other projects where such a device has been implemented and the level of success that was achieved.

Information regarding adult and juvenile habitat requirements of fish by species, water temperature requirements of fish by species, spawning/rearing/holding habitat requirements, predation risks, susceptibility of each species to various capture conditions, and species response to stress and loss will be obtained from Task 1 and will used to evaluate species-specific components associated with each type of release mechanism.

- Site condition summaries of existing passage barriers and study reaches (Task 4A);
- Develop a matrix of alternatives/locations that will provide an indication of the gated process and explore the following issues (Task 4B):
    - For each phase in the analysis, list the alternative methodologies and mechanisms that could provide fish passage;
    - A weighted description and evaluation of each mechanism (based on the literature review) in order to determine unit-less ranking profiles (i.e. highly feasible, potentially feasible, not feasible);
    - Identify possible options to modify the scores (i.e. if by changing one factor, the alternative would become feasible);
- GIS decision support tool (Task 4C):
    - This tool will draw upon information that is provided by the weighted matrix (4B) and the set of maps listed in Task 2 to provide a means of evaluating the feasibility of all possible combinations of fish passage alternatives. This decision support tool will be used to facilitate negotiation of all PM&Es.

Products/Deliverables

The study plan summary report will include:

- Executive Summary
- Table of Contents
- List of Tables
- List of Figures
- Introduction
- Methodology
- Narratives of relevant findings by task
- Discussion addressing most relevant questions (see above) and indicating any complications/data concerns
- Conclusions related to study plan goals and objectives
- References
- Appendices

7.0 Coordination and Implementation Strategy

Coordination with Other Resource Areas/Studies

Completion of this study plan will require information from other resource study plans being prepared for the Oroville Facilities FERC Relicensing Project including engineering and operations, geomorphology, water quality, terrestrial, and other fisheries study plans. Coordination among study plans is currently underway to ensure consistency and efficiency in obtaining needed information. A preliminary list of study plans that will require coordination with this study plan include:

- SP-F3.1- Evaluation of Project Effects on Resident Fish and Their Habitat within Lake Oroville, the Thermalito Complex and Upstream Areas Within the Project Boundaries.

Tasks in SP-F3.1 (1B, 2A, 3A, 4A, and 5A) will provide SP-F15 with life history and habitat requirements for fish in Lake Oroville and Lake Oroville's upstream tributaries up to the first migration barrier above Lake Oroville for use in similar tasks (Tasks 1, and 2) in SP-F15. SP-F3.1 evaluates the project effects on resident fish habitat within Lake Oroville, the Thermalito Complex and in the upstream tributaries below the first migration barrier above Lake Oroville. Information characterizing the availability and suitability of upstream fish habitat conditions, developed in SP-F3.1, will be reviewed and adapted for use in the evaluation of anadromous salmonid habitat conditions. It is noted that SP-F3.1 will rely on other resource study plans to compile this detailed information. Habitat components from SP-F3.1 that will identify fish habitat below the first migration barrier above Lake Oroville include:

- Mesohabitat maps provided by SP-G1;
- Substrate characterization, transect data, channel morphology, assessment of woody debris, and cover cross-sectional monitoring data including water depth, velocity, and turbidity obtained from SP-G1;
- Inundation flow boundaries at various flow levels interpolated from SP-G1 channel transects;
- Vegetation survey results (grass, shrub, bush, tree classes) obtained from SP-T4;
- Data from SP-G1 used in the analysis of passability of sediment plugs within the fluctuation zone of Lake Oroville;
- Water temperature data obtained from SP-W6;
- Water quality data obtained from SP-W1; and
- Exceedances of water quality recommendations for freshwater aquatic life obtained from SP-W1.

The information to be obtained from SP-F3.1 will also consider the availability of habitat for adult and juvenile anadromous salmonids between the Fish Barrier Dam and Thermalito Diversion Dam as well as the area above Oroville Dam.

- SP-F3.2-Evaluation of Project Effects on Non-salmonid Fish in the Feather River Downstream of the Thermalito Diversion Dam

SP-F3.2 will provide SP-F15 with life history and habitat requirements for fish in the Feather River downstream of the Thermalito Diversion Dam for use in similar tasks (Tasks 1 and 2) in SP-F15. Habitat components from SP-F3.2 that will be ~~considered~~ utilized in order to identify fish habitat (Task 2) include:

- Mesohabitat maps including pools, riffles, glides (existing maps require registration and digitizing);
- Substrate characterization, transect data, channel morphology, assessment of woody debris, and cover cross-sectional monitoring data including water depth, velocity, and turbidity obtained from SP-G2;
- Inundation flow boundaries at various flow levels interpolated from SP-G2 channel transects;
- Vegetation survey results (grass, shrub, bush, tree classes) obtained from SP-T4;
- Water temperature data including water temperature measurements to the confluence of the Sacramento and Feather rivers in both riffles and deep pools obtained from SP-W6;
- Water quality data including turbidity and dissolved oxygen measurements obtained from SP-W1;
- Exceedances of water quality recommendations for freshwater aquatic life obtained from SP-W1;
- Macroinvertebrate community characteristics obtained from SP-F1; and
- Flow data obtained from USGS gaging stations.
- SP-F5/7—Effects of Fisheries Management on Project Fisheries

SP-F5/7 will provide information regarding stocking and non-stocking fisheries management activities with respect to the Endangered Species Act and for a description of the interactions of managed reservoir fisheries and riverine fisheries in the study area.

- SP-F8-Transfer of Energy and Nutrients by Anadromous Fish Migrations

SP-F8 will provide SP-F15 with information regarding historical escapement and estimates of potential maximum escapement of chinook salmon given the existing habitat of the tributaries upstream of Lake Oroville.

- SP-F10-Evaluation of Project Effects on Anadromous Salmonids and their Habitat

Information on the Feather River anadromous salmonid specific life history and habitat requirements will be provided by SP-F10 and will be used in SP-F15 for each of the three target species (fall-run chinook salmon, spring-run chinook salmon, and steelhead). Graphical representations of the life stage periodicity also will be obtained from SP-F10 for these three species. This information will include collection and compilation of information on the habitat suitability characteristics of Chinook salmon and steelhead. The following topics will be included in the description:

- Adult upstream migration (timing, and prevalent water temperature and flow conditions);
- Adult holding habitat (habitat availability, water temperature, holding pool or stream characteristics);
- Spawning (habitat availability and suitability, abundance and distribution, timing, and factors affecting timing and success such as substrate conditions and water temperatures);
- Early development (factors affecting embryo incubation survival through emergence);

- Juvenile rearing (habitat availability and utilization, distribution and abundance, water temperature, substrate characteristics, refuges, shade, cover, food availability, predation, stranding); and
- Juvenile outmigration and movements (timing, prevalent flow, water temperature and other abiotic conditions).

- SP-F21-Project Effects on Predation of Feather River Juvenile Anadromous Salmonids

SP-F21 will provide information to SP-F15 regarding the extent of predation on juvenile salmonids and the physical environment created by passage intakes and bypass structures associated with predation will be considered in the completion of this study plan.

- SP-G1 – Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam

SP-G1 will provide information to SP-F15 regarding hydraulic transport conditions at a variety of flow rates when reservoir levels are low and the river is actively flowing. Engineering and Operations Work Group Studies and Models

The descriptions and evaluations of study area characteristics will incorporate the results from hydrologic and water temperature modeling completed for the project. Preliminary, anticipated specific information to be obtained include:

- Daily and monthly flow fluctuations between the Feather River Fish Barrier and Oroville dams;
- Daily and monthly mean water temperatures between the Feather River Fish Barrier and Oroville dams;
- Lake Oroville water level fluctuations; and
- Lake Oroville water temperature profiles.

Issues, Concerns, Comments Tracking and/or Compliance Requirements

Stakeholder Issues Fully Addressed by the Evaluation of the Feasibility to Provide Passage for Anadromous Salmonids Past Oroville Facility Dams Study Plan

Issue	Description
FE10	Provide for fish passage on any drainage or stream where spawning activity occurs.
FE14	Provide for fish passage and maintain natural channel character at stream crossings within project area and/or project-affected areas.
FE62	Reintroduce anadromous fish above dam.
FE85	Impact of project facilities and operations on fish passage includes structures, flows, and/or water quality conditions that impede or block passage within and from current and/or historic habitat and operations that impact passage or have the potential to enhance passage. Passage includes movement of spawning or holding adults, emigrating smolts, and juveniles searching for areas where to feed, avoid predators, or shelter.
FE 91	Current conditions of habitat potentially impacted by project and alternatives to conserve or enhance anadromous salmonids.
FE98	Fish passage is an essential survival element for anadromous species and obstructed passage can also have serious adverse impact on resident species biodiversity and populations. Both upstream and downstream unobstructed fish passage below the project should occur. Fishery investigations should examine the adequacy of passage for all species in the reaches of the lower Feather River downstream of the project. Evaluations should cover a sufficient range of flows and include examination of instream pits or gravel ponds.

Source: NEPA Scoping Document 1 and CEQA Notice of Preparation, DWR 2001.

Stakeholder Issues Partially Addressed by the Evaluation of the Feasibility to Provide Passage for Anadromous Salmonids Past Oroville Facility Dams Study Plan

Issue	Description
FE 64	Effect of project on available upstream fishery habitat (incorporate all project facilities); also addressed in SP-F3.1.

Source: NEPA Scoping Document 1 and CEQA Notice of Preparation, DWR 2001.

8.0 Study Schedule

The literature review associated with Tasks 1, 2, 3 and 4 of SP-F15 will begin during the summer of 2002, pending plenary approval, and will be completed by December 2003. Periodic verbal reports will summarize the preliminary results of the literature review identifying and describing the information relating to Tasks 1, 2, 3, and 4. These iterative reports will provide updates to the collaborative throughout the study design and implementation process and will facilitate discussion regarding potential adjustments to the focus of the analysis.

9.0 References

A complete list of references used in the completion of the study will be part of the summary report. The references cited in the present plan are listed below.

Castillo, G., M. Meleason, and E. Philips, 1994. Annotated Bibliography on Fishery Questions Related to the Reintroduction of Anadromous Fish Over High Head Dams, December 1994.

DFG. 1952. Fisheries problems of the Feather River with special reference to the proposed Oroville Dam. October 30, 1952.

DWR. 2000. 1999 Lake Oroville Annual Report of Fish Stocking and Fish Habitat Improvements, February 2000.

DWR. 2001. Initial Information Package, Relicensing of the Oroville Facilities, January 2001.

DWR and USBR. 2000. Biological Assessment: Effects of the Central Valley Project and State Water Project on Steelhead and Spring-run Chinook Salmon, November 2000.

PG&E Poe or North Fork Feather River Application

Sommer, T., D. McEwan, and R. Brown. 2001. Factors affecting chinook salmon spawning in the lower Feather River. Pages 269-297 in R.L. Brown, editor. Contributions to the biology of Central Valley salmonids. California Department of Fish and Game Fish Bulletin 179.

Yoshiyama, R. M., E. R. Gerstrung, F. W. Fisher, and P. B. Moyle. 1996. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California in Sierra Nevada Ecosystem Project. Final Report to Congress, vol. III: Assessments, Commissioned Reports and Background Information. (University of California, Davis, Centers for Water and Wildland Resources, 1996.)

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18: 487-521.